



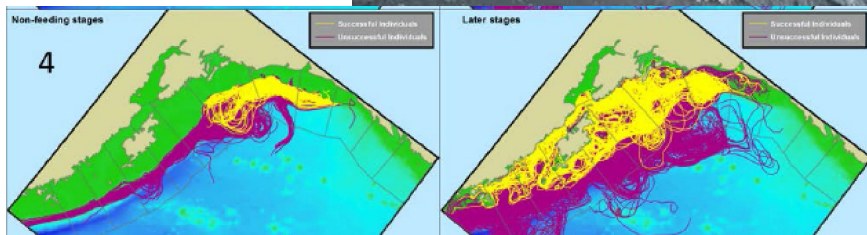
**NOAA**  
**FISHERIES**

# Integrated Project: Gulf of Alaska Project

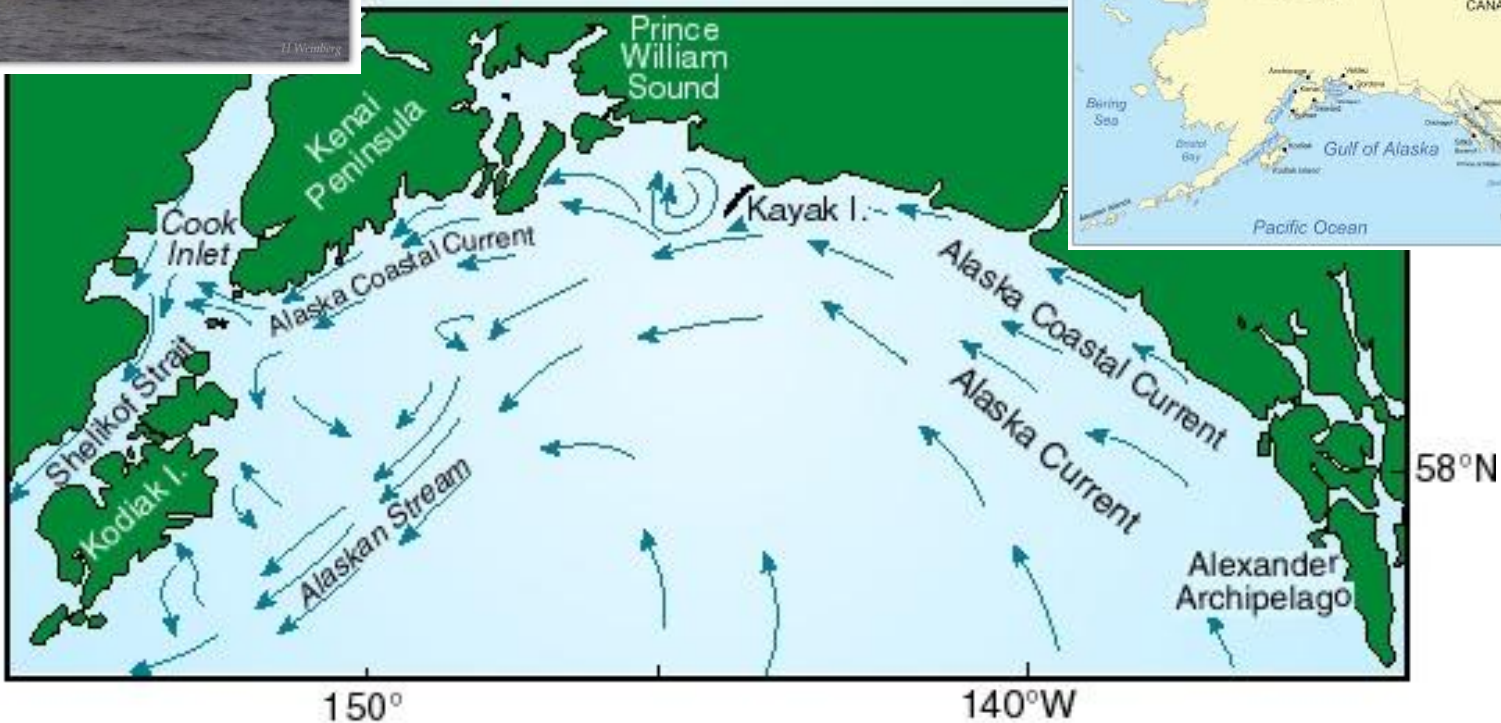
Ron Heintz

Ecosystem Science Review  
Juneau, Alaska  
May 2-6, 2016

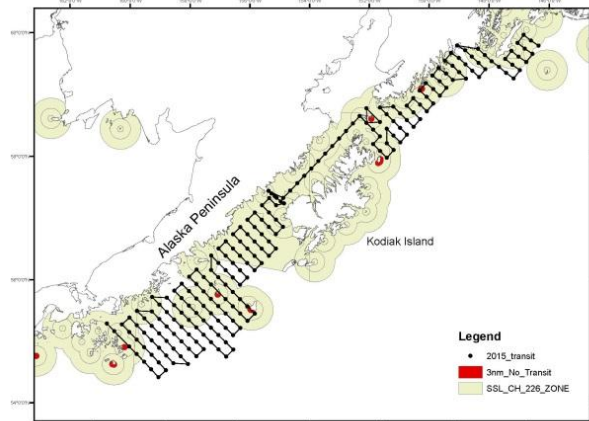
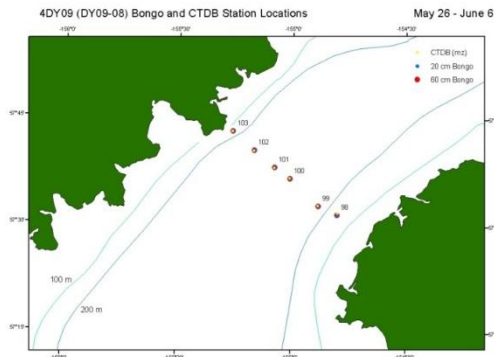
# The Gulf Ecosystem Survey Integrates Oceanography, Fishing, and Laboratory Data to Monitor Recruitment Processes.



# Gulf of Alaska Is an Important Source of Protein

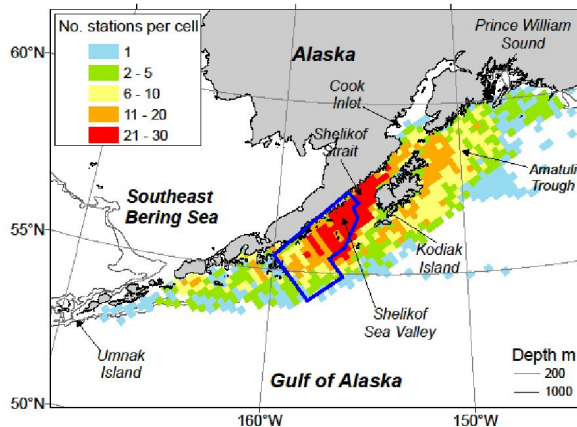


# The Gulf Survey Evolved Out of Ecosystem Surveys Conducted by AFSC Starting in 1981



Zooplankton  
Spring 2010 -  
Present

Line 8 in Shelikof Strait (Chlor, Nut, Bongo, MZ)  
Spring 1985-Present



Larval fish sampling since 1981

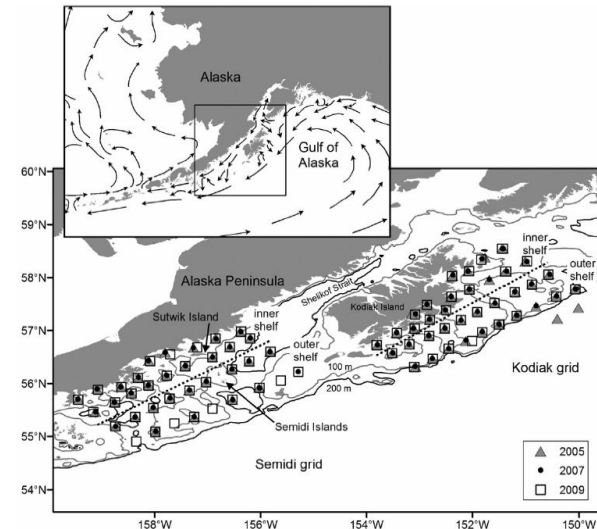


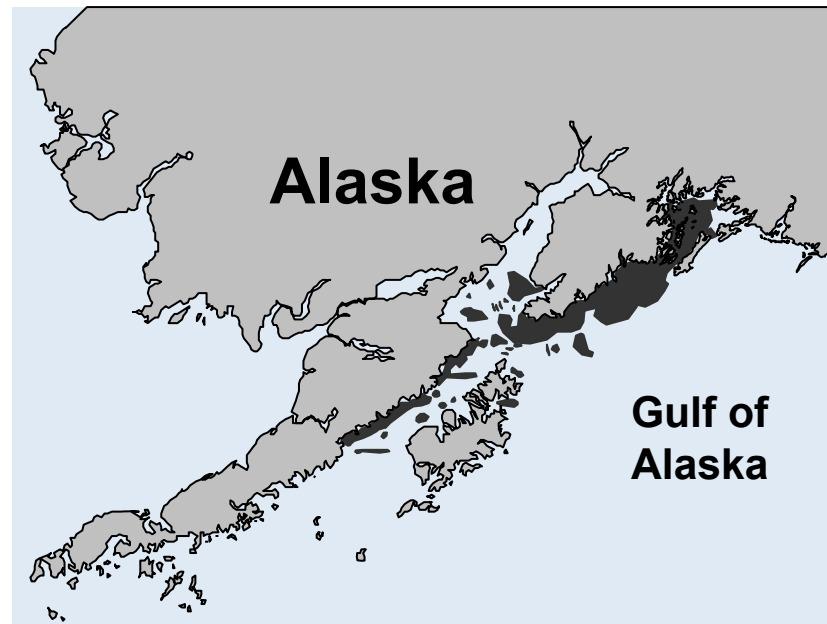
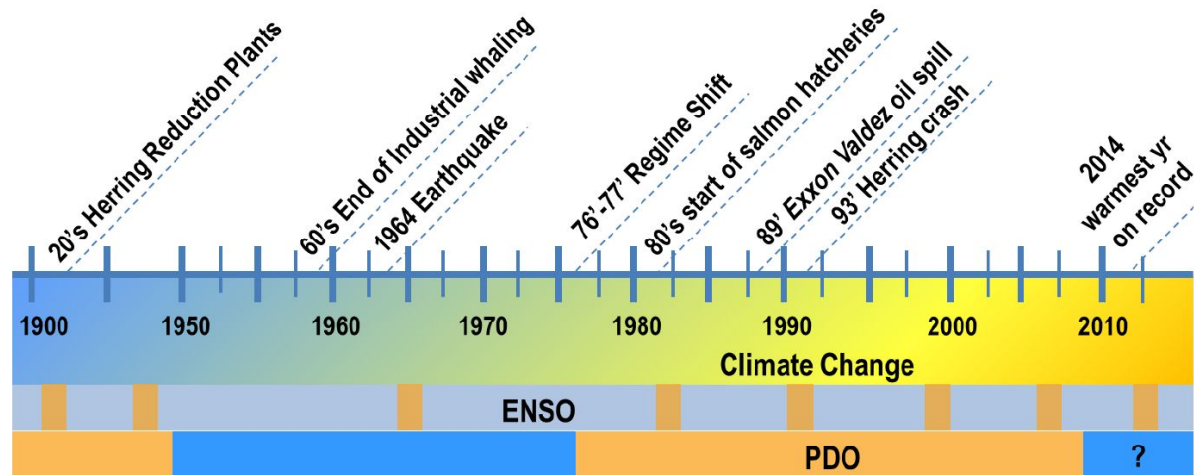
Figure 1. Map of ocean currents (top, from Reed and Schumacher, 1986) and sites in the GOA (bottom) where sampling was conducted during September 2005, 2007, and 2009 to measure water temperature and salinity, and to collect zooplankton and age-0 walleye pollock. Each grid is divided (dotted line) into inner-shelf and outer-shelf area.

Forage fish research since 2001

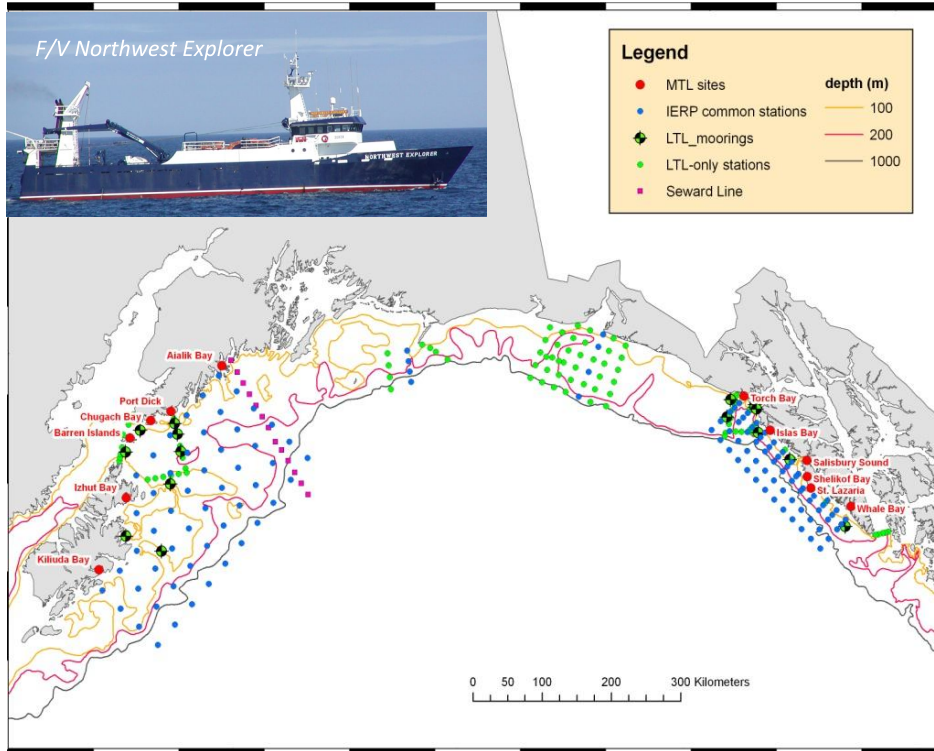
# Ecosystem Monitoring in the Gulf of Alaska

## EVOSTC Supported Datasets:

- **Oceanographic**
  - GAK-1 (45 yrs)
  - Seward Line (20 yrs)
  - Continuous Plankton Recording (20 yrs)
- **Biological**
  - Killer whales (32 yrs)
  - Marine Birds (25 yrs)
  - Herring (26 yrs)
- **Established NPRB**

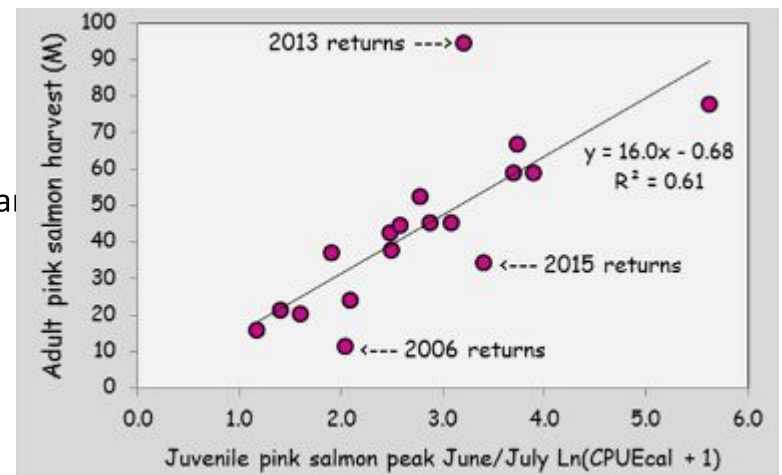


# Gulf of Alaska Assessment



- 1996 – 2004: late summer – cross shelf transects – integrated ecosystem survey focus on Pacific Salmon
- 2010 – Present: summer – systematic grid – integrated ecosystem survey focus on groundfish/Pacific salmon
- Oustide Funding (NPRB, AKSSF, PSC, Globec)

Goal: Connect climate change and variability to ecosystem function and



# How does the Gulf Ecosystem Survey Relate Fish to Environmental Conditions

Eastern Grid – annually

Western Grid – Semi-annually

## Station Activities

CTD

Water chemistry

Chl-A

Zoops small mesh

Zoops large mesh

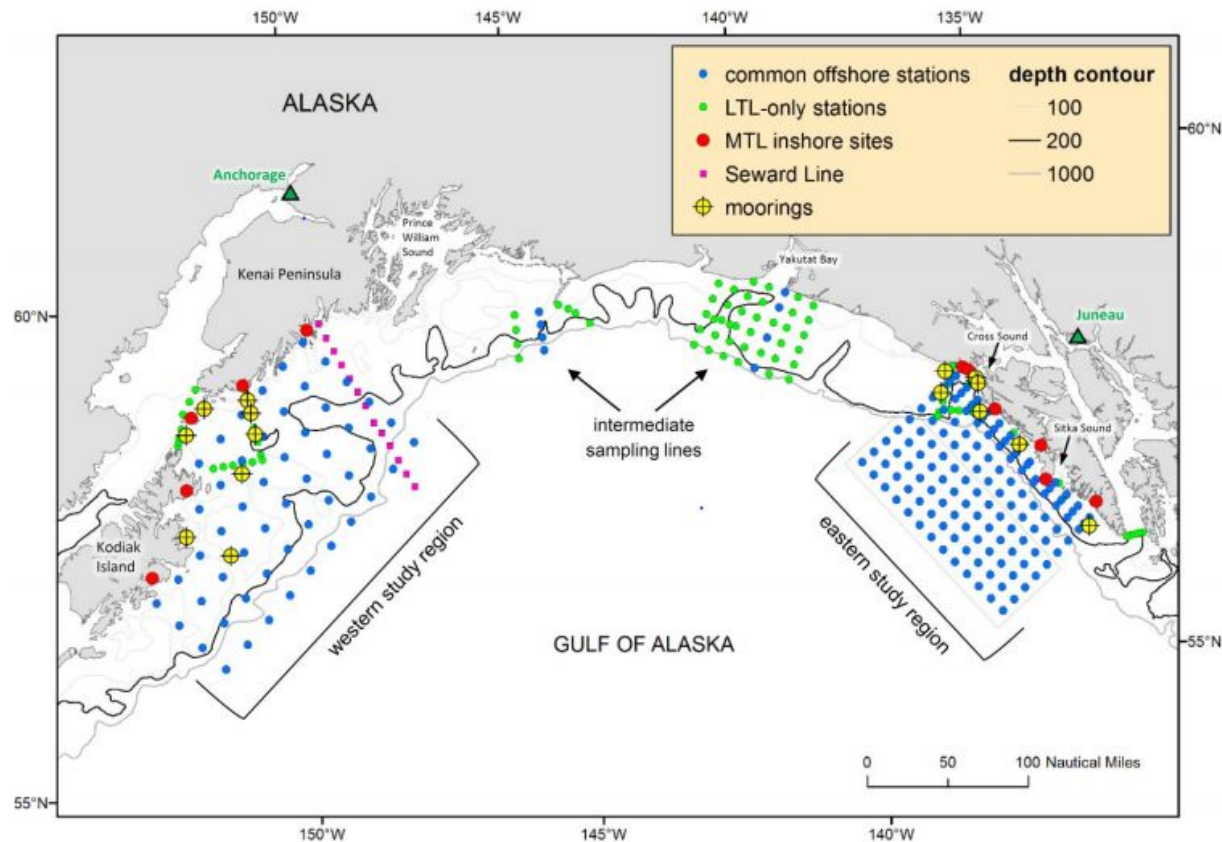
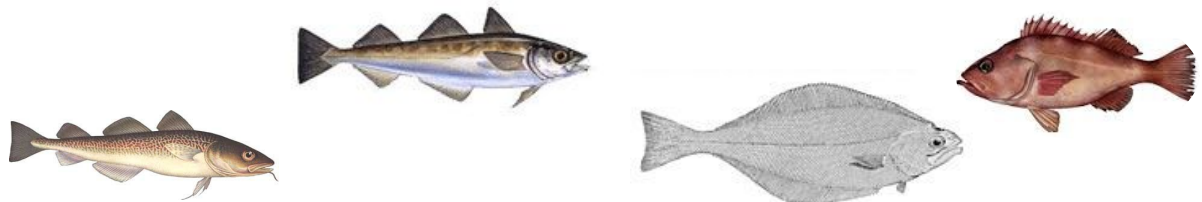
Trawl

Count

Size

Diet

Energy



NOAA FISHERIES

# Why Monitor Recruitment Processes?

1. Improve stock assessments
2. Connect production to environmental conditions

Sensitivity to Environmental Conditions

Higher



Lower



# Application of Bioenergetics to Understand Recruitment Processes

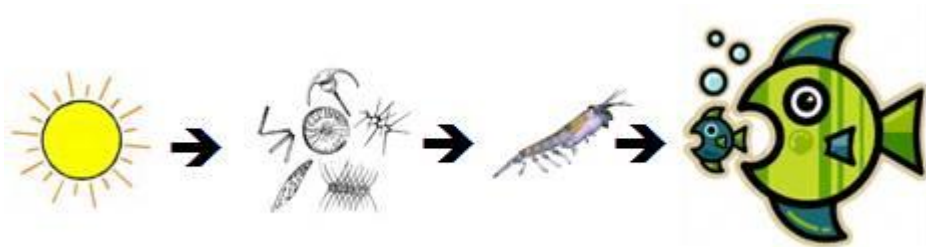
$$\text{Growth} = \text{Consumption} - \text{Respiration} - \text{SDA} - \text{Egestion}$$

Integrates –

Temperature

Food quality

Food Availability (Production, Competition, Predation)



# Comparison of Pollock and Cod Growth in GOA

$$\text{Growth} = \text{Consumption} - \text{Respiration} - \text{SDA} - \text{Egestion}$$

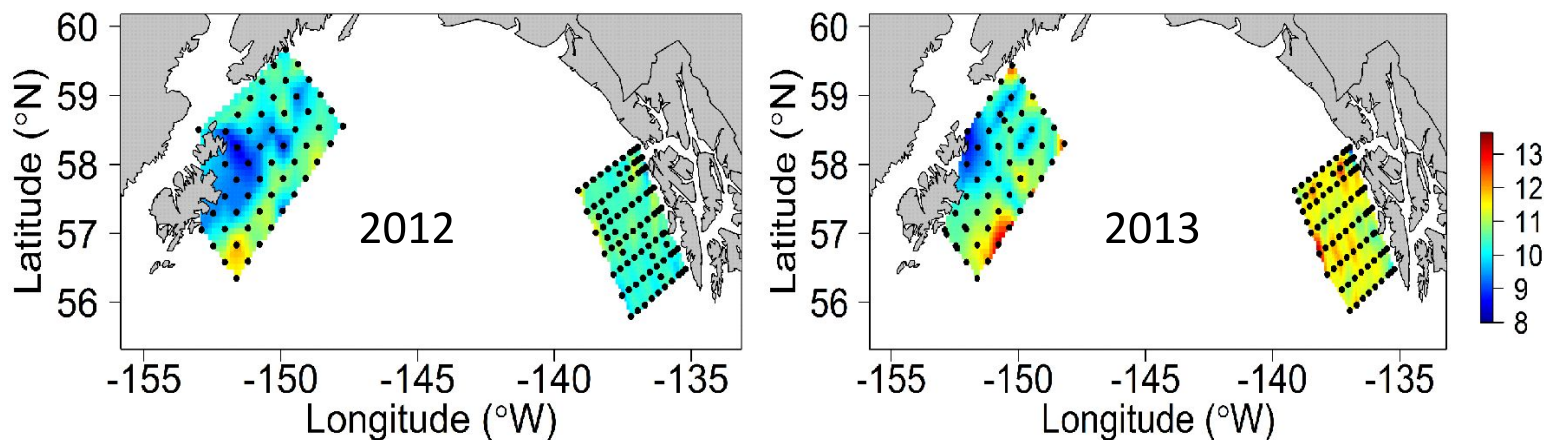
## Approach

Estimate growth potential at each station

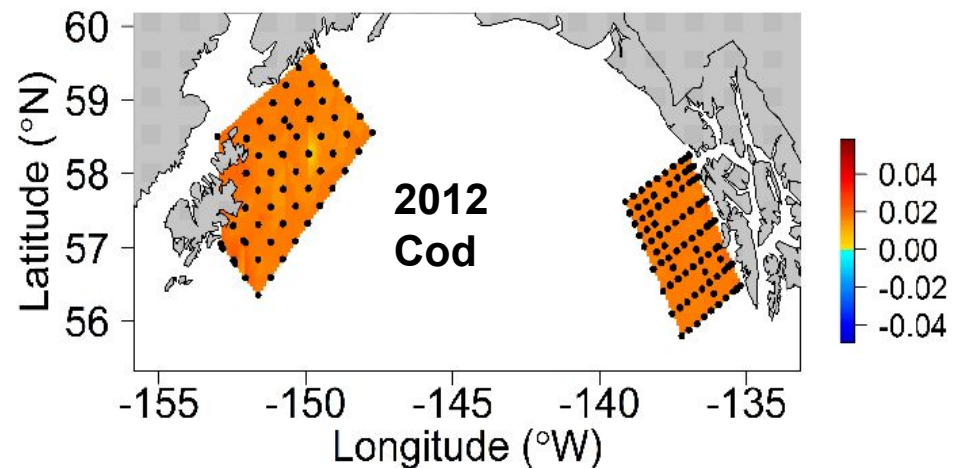
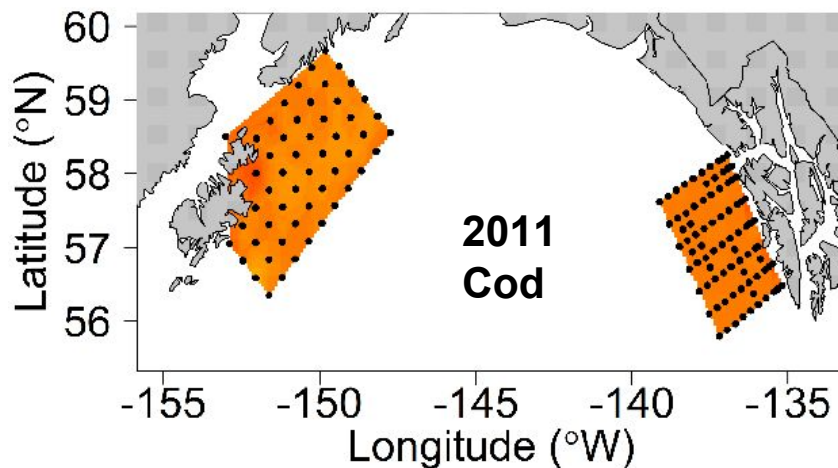
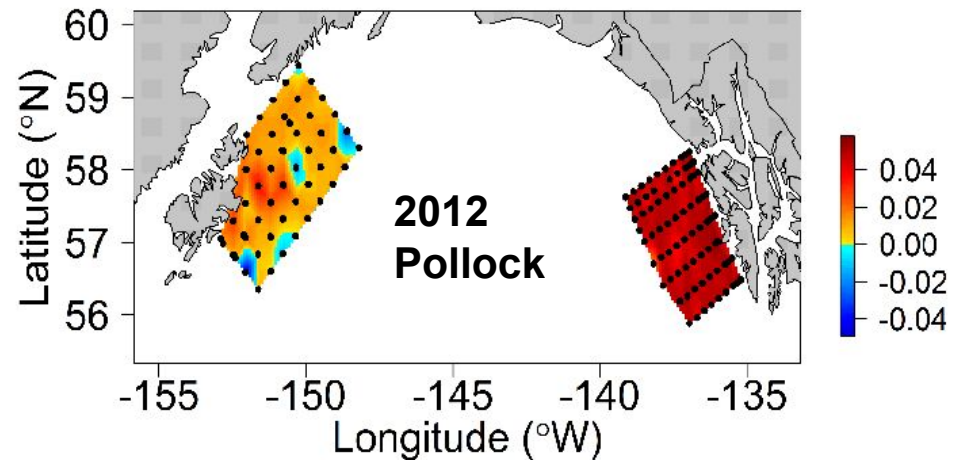
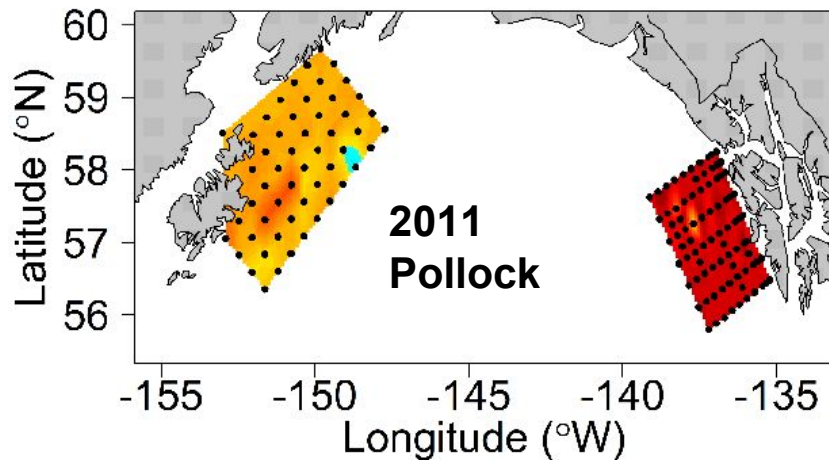
Assume Cmax, constant size

Use ambient temperature, diet quality

## Temperature

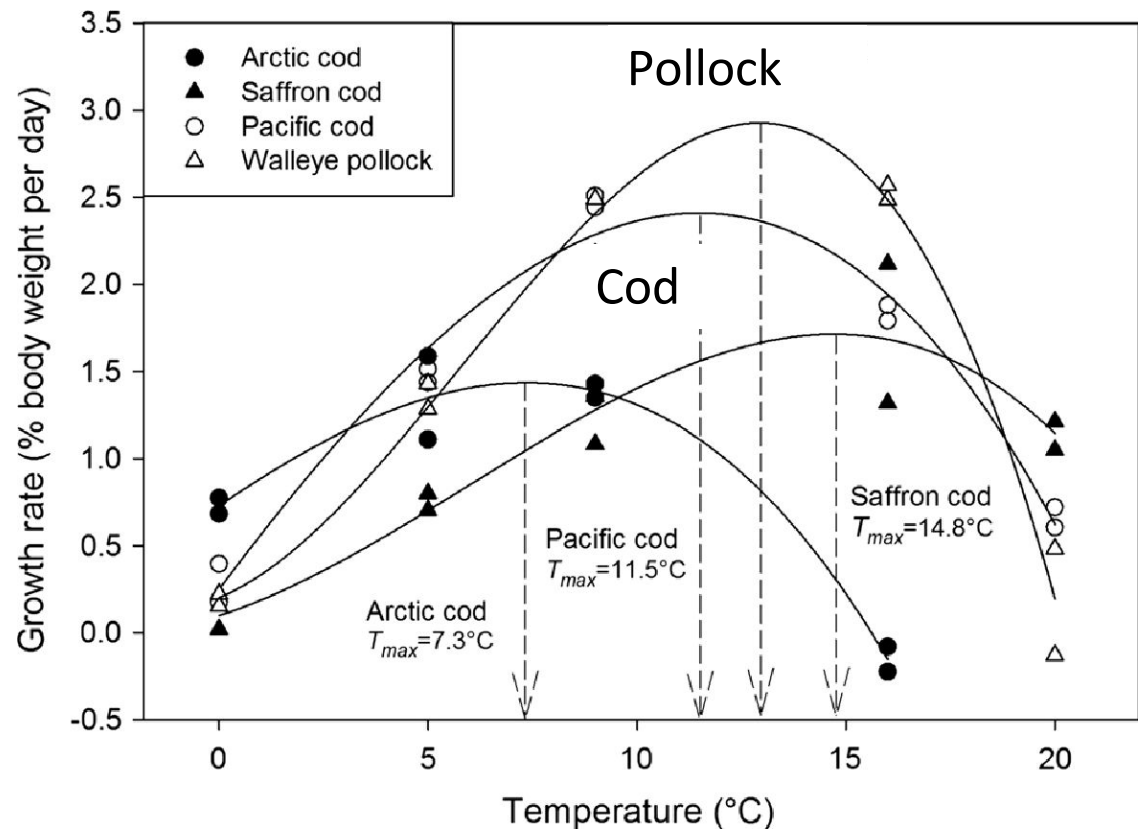


# Growth Potential for Pollock and Cod In Eastern and Western GOA

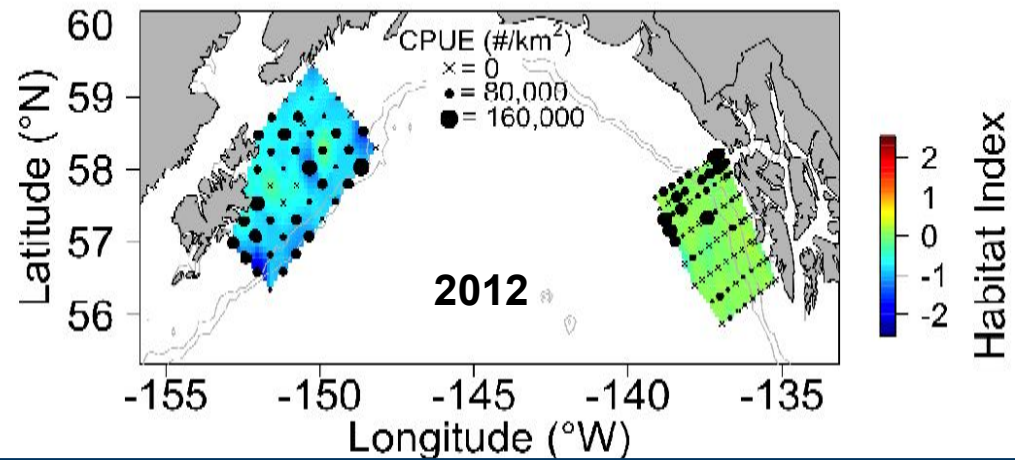
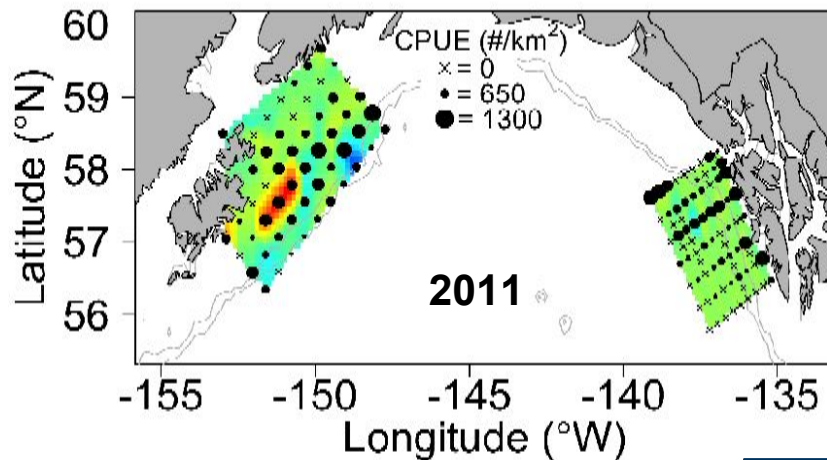


# Pollock Better Able to Respond to Optimal Conditions

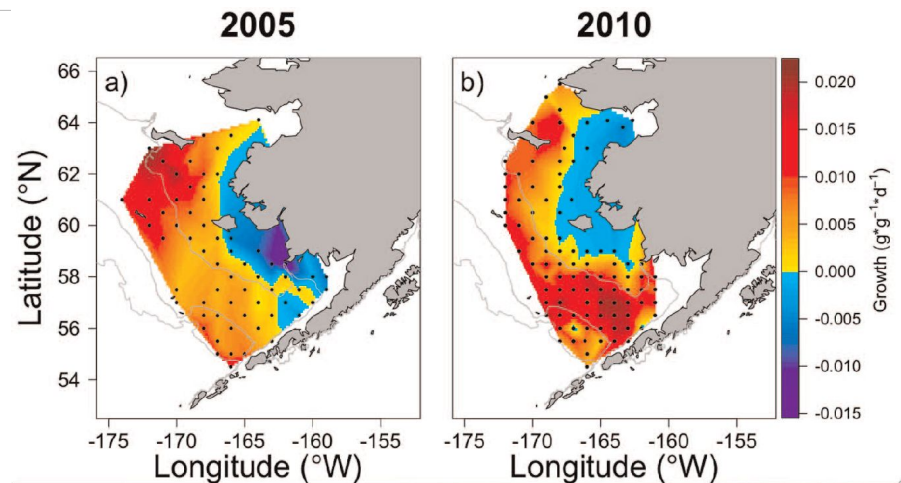
- Pollock most sensitive to changes in prey quality
- Cod growth unaffected by changes in prey quality or temperature



# Patchy Distribution of Locations Favoring Pollock Growth



- Pollock habitat spotty
- Cod habitat ubiquitous

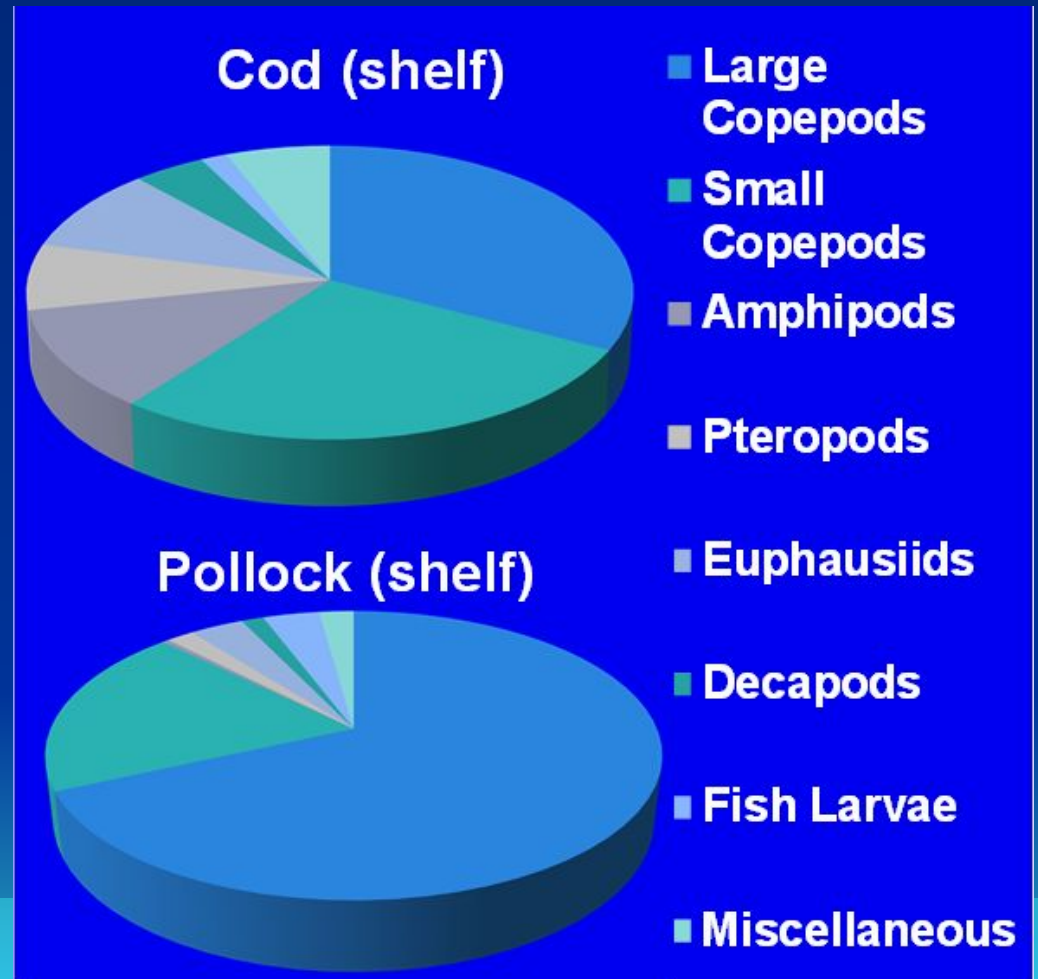


Pollock not always matched with good habitat

# Food: Diets

## Pacific cod vs. walleye pollock

- Cod diets more diverse
- Pollock consumed more large, lipid-rich copepods
- Few euphausiids



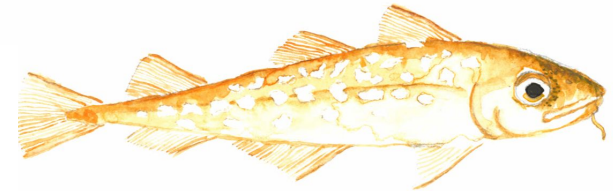
Zaleski, Moss,  
Heintz

# Age-0 Cod and Pollock Employ Distinct Strategies

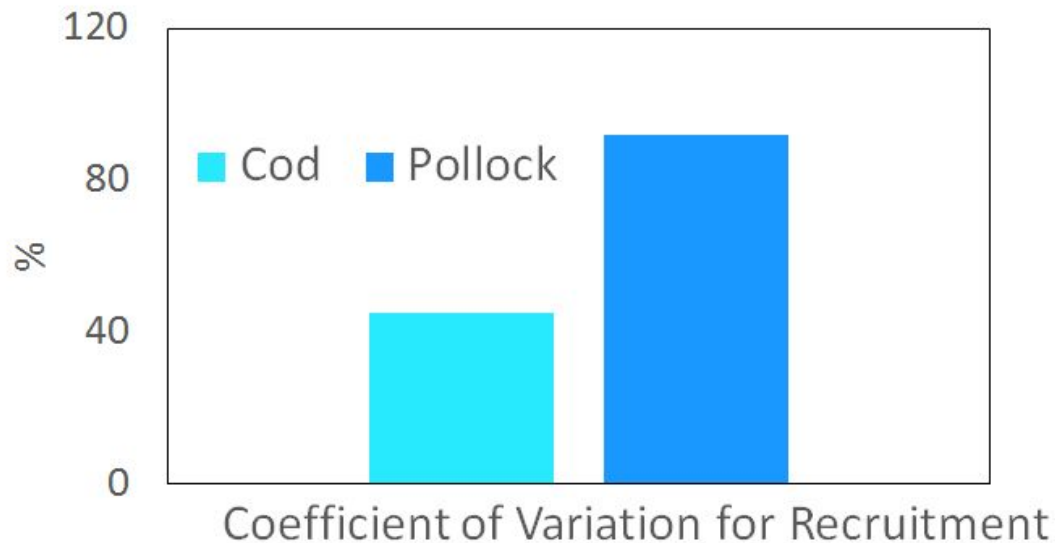


Walleye pollock  
*Gadus chalcogrammus*

Pollock – Sweepstakes Strategy  
Larvae spread over broad spatial area,  
strong response to optimal conditions



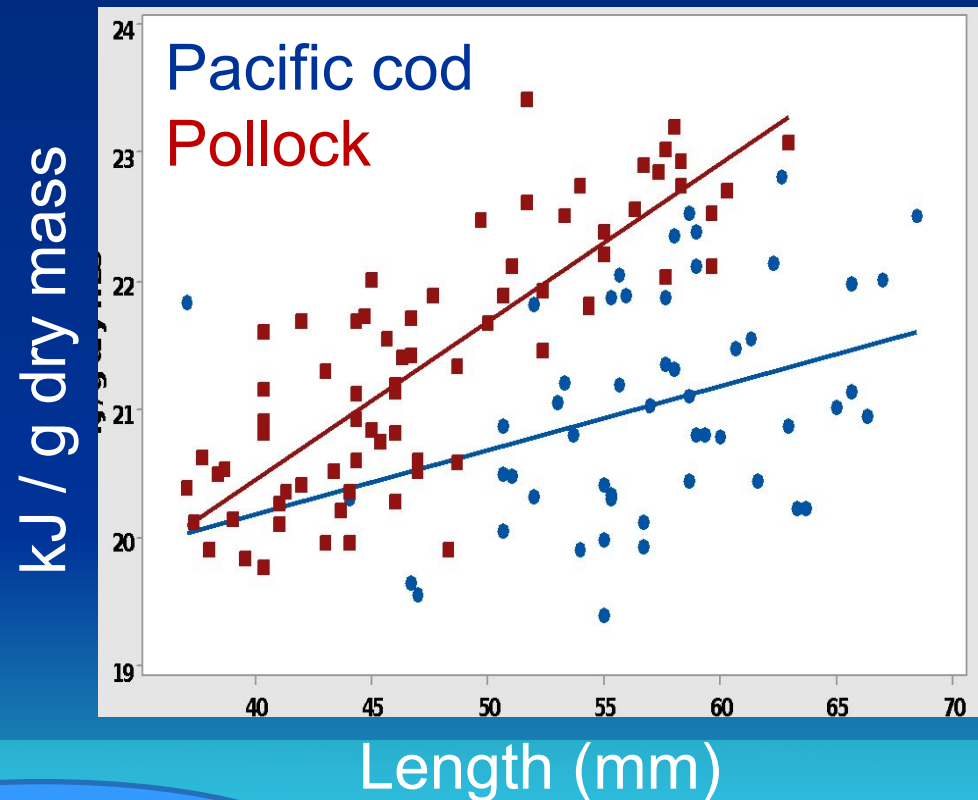
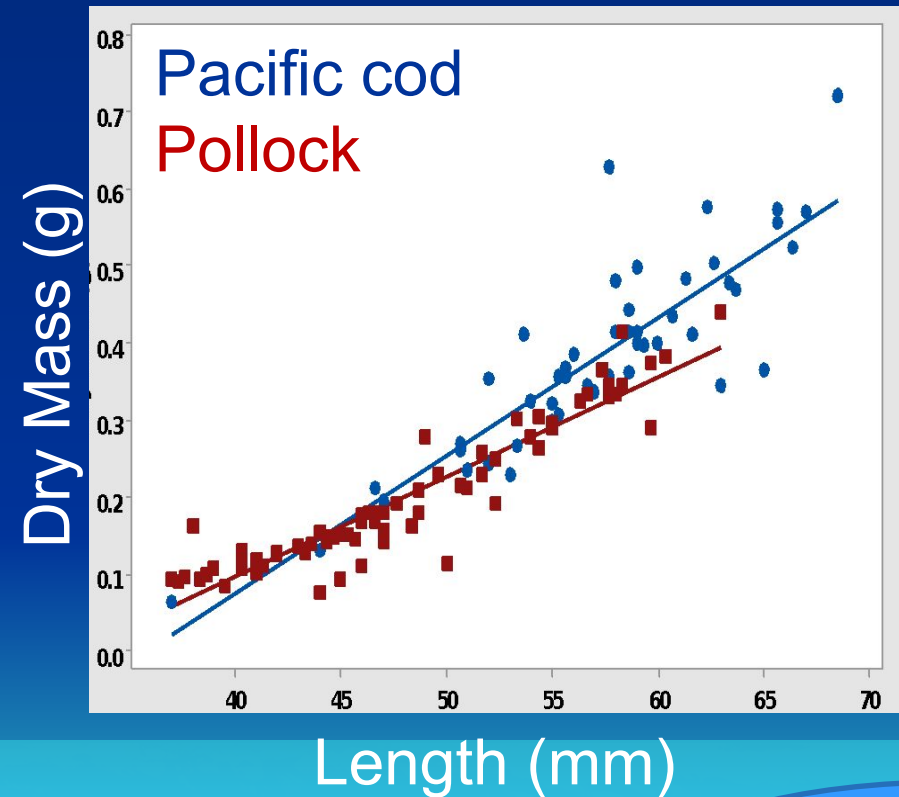
Pacific cod  
*Gadus macrocephalus*



Cod – Steady Strategy  
Larvae retained in spawning  
location, response tuned  
to average conditions

# Food: Energy Allocation strategies

- Cod are heavier than pollock at a given size (muscle mass)
- Pollock allocated more energy to lipids (energy stores)

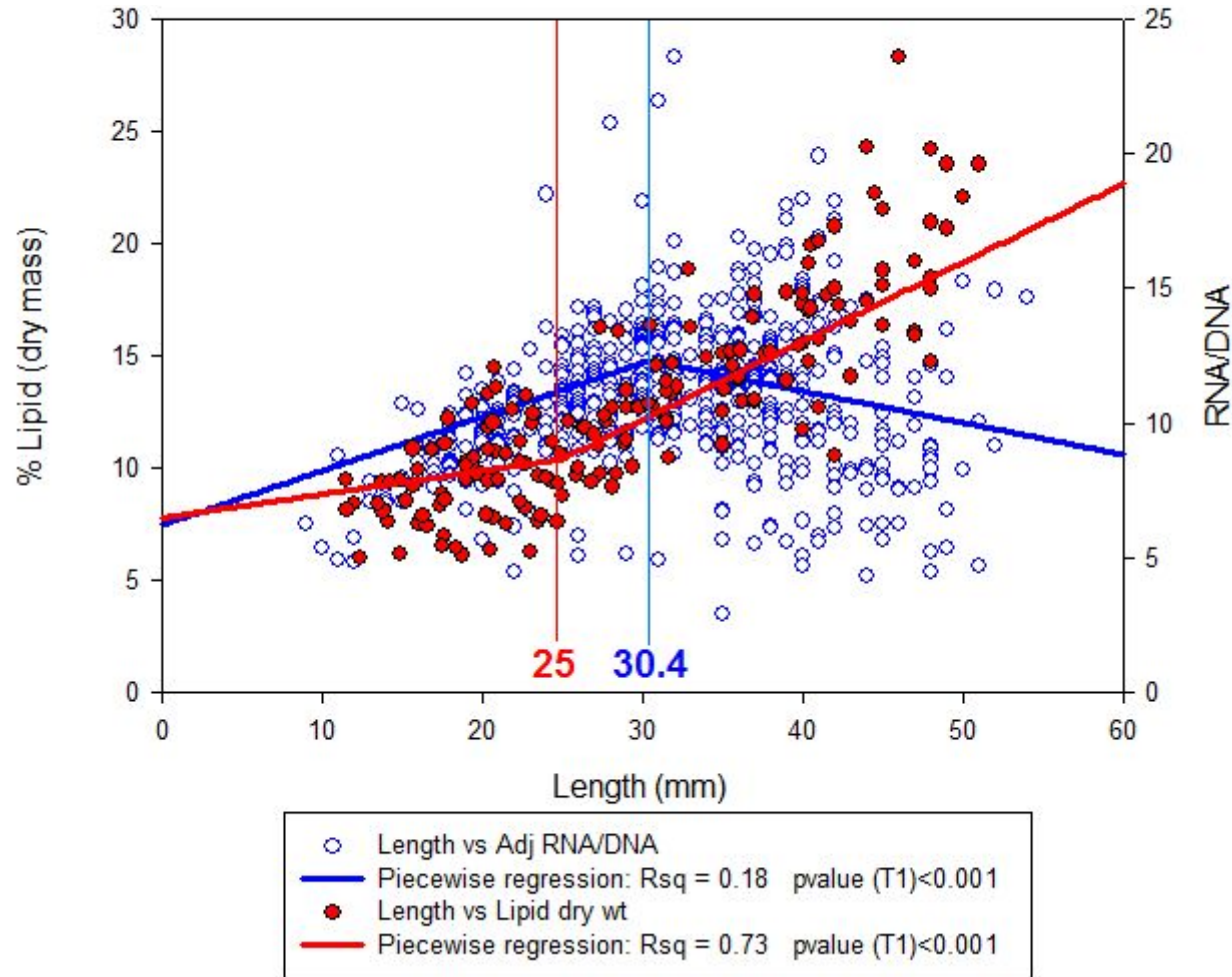


Moss, Zaleski,  
Heintz

# What Can We Learn from Energy Allocation Strategies?

- Identifies important life history stages – migration, reproduction, winter, settling out
- How prevalent are the various strategies?
- Is there a relationship between strategy and survival constraints?
- What is the relationship between environmental variation and strategy?

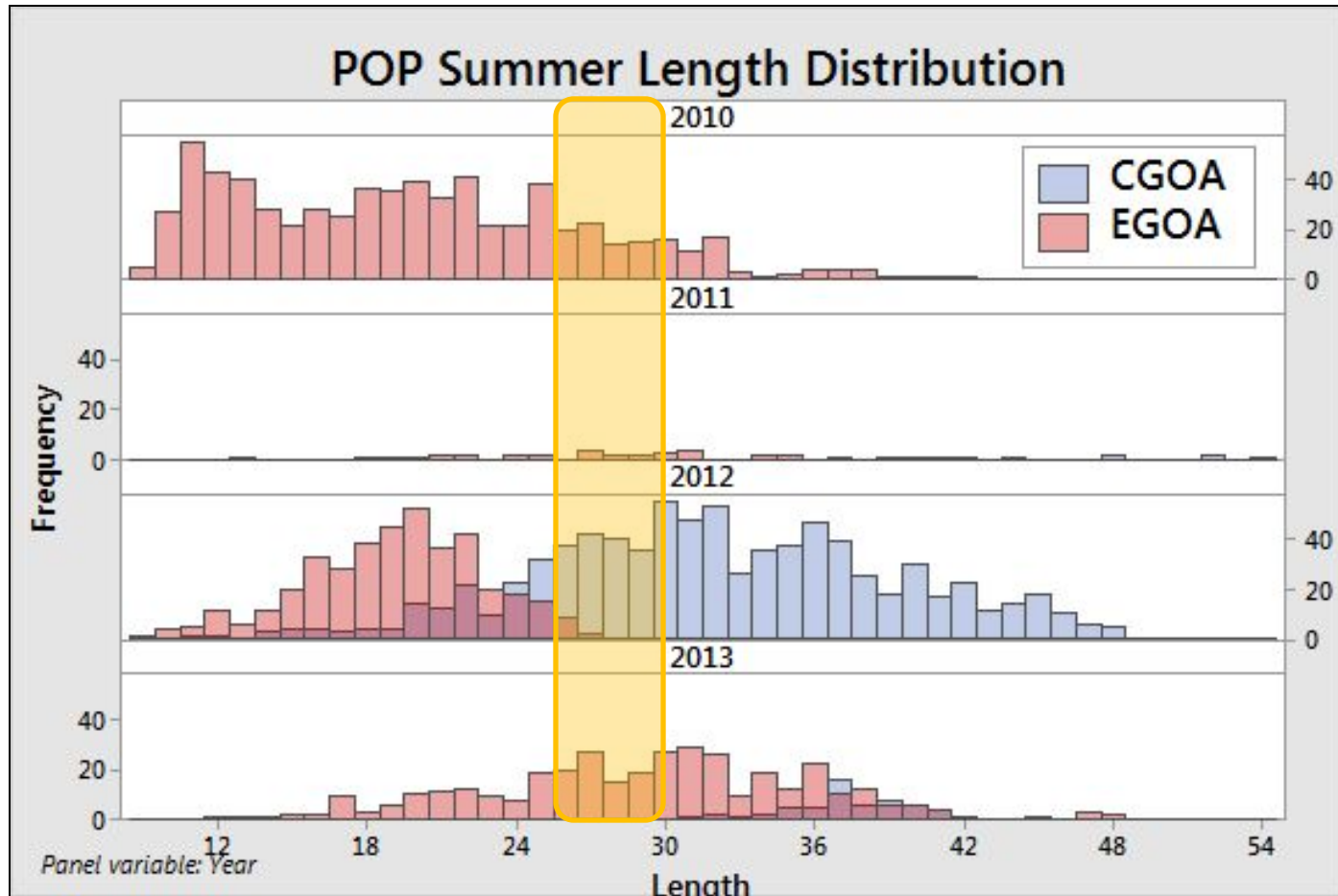
# Juvenile POP Energy Allocation



% Lipid= energy storage

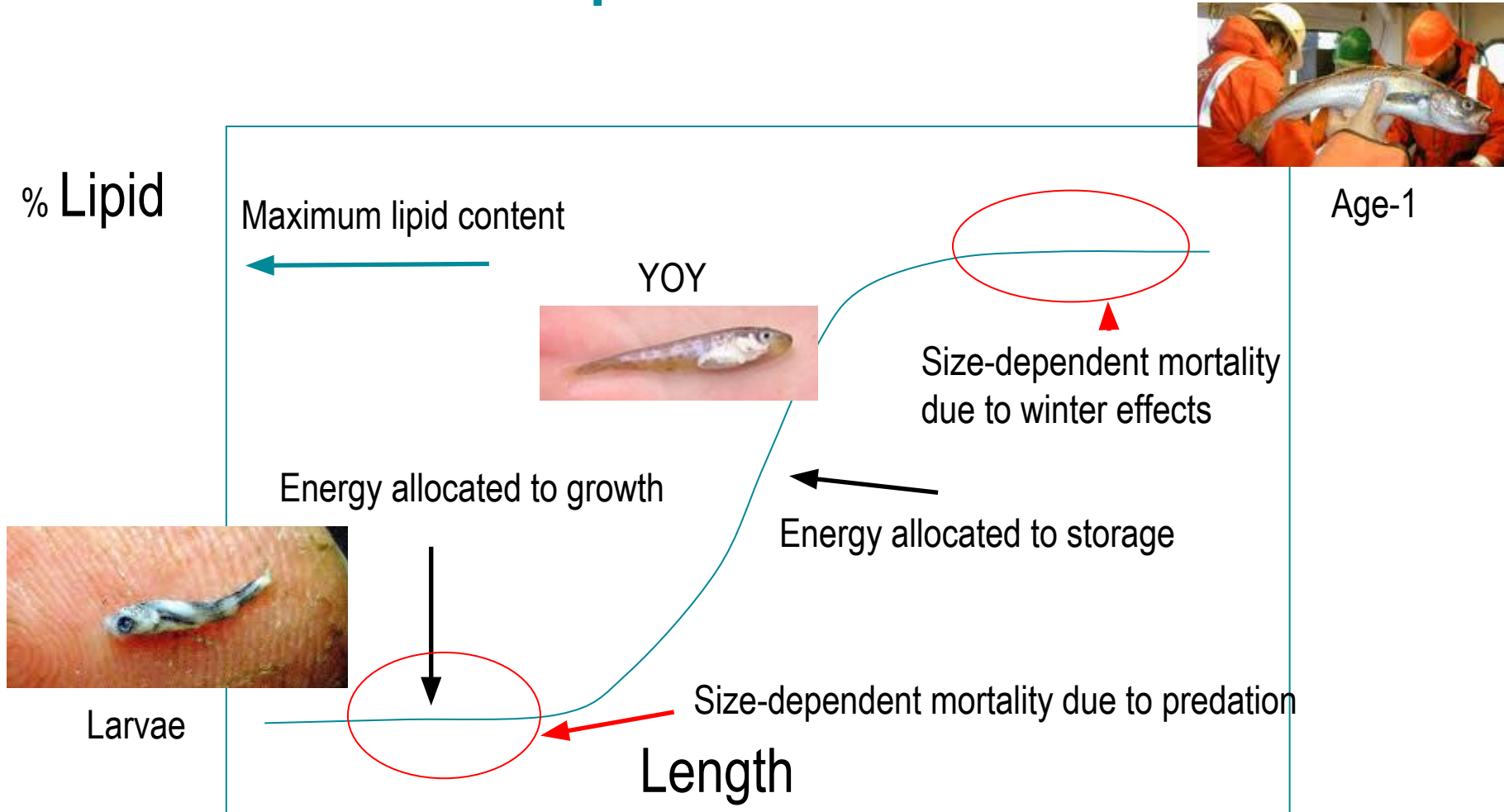
RNA=protein synthesis (growth)

# Summer Critical Size for Juvenile POP

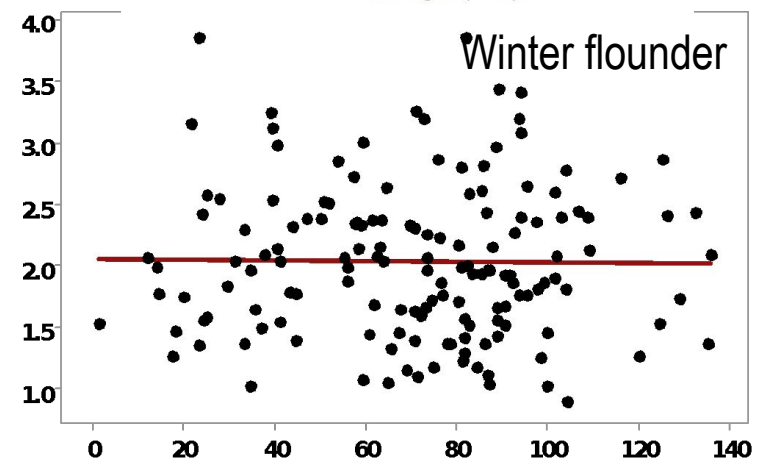
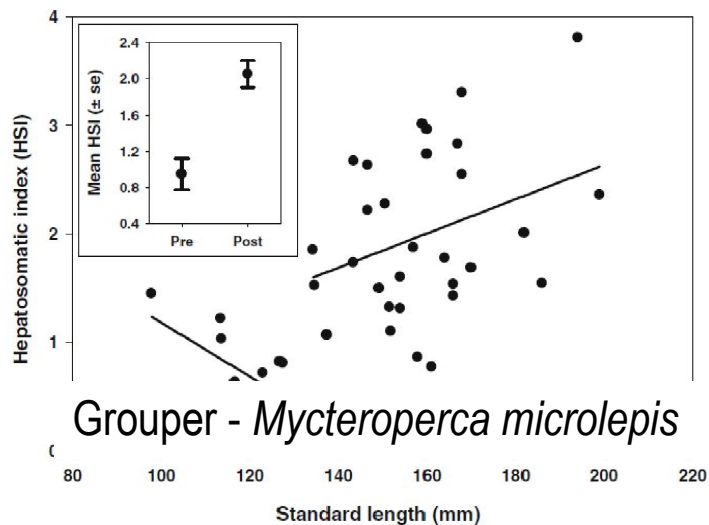
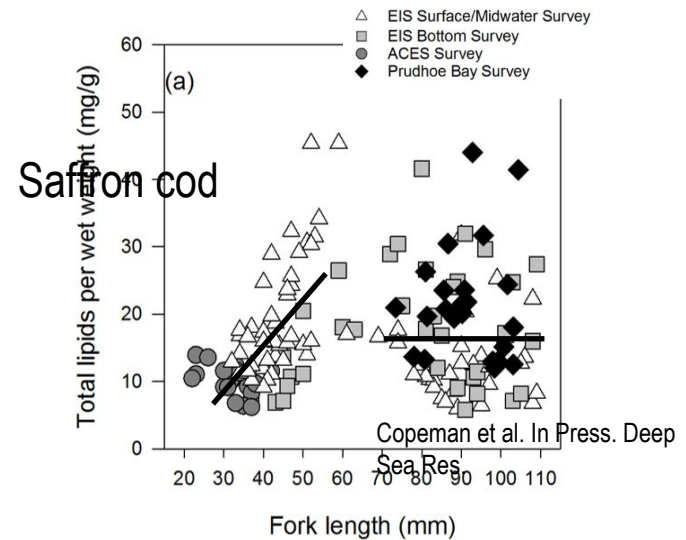
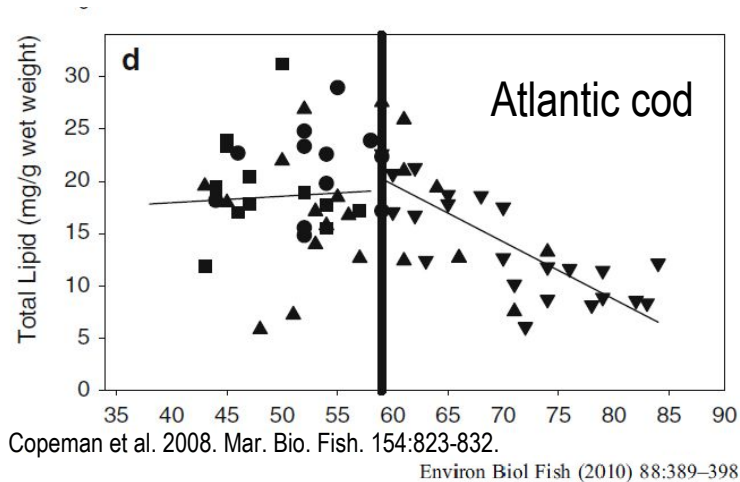


Proportions of cohort that achieve critical size is variable across years.

# Juvenile Energy Allocation States at High Latitudes a Response to Perceived Risk



# Other Energy Allocation Strategies Can Exist

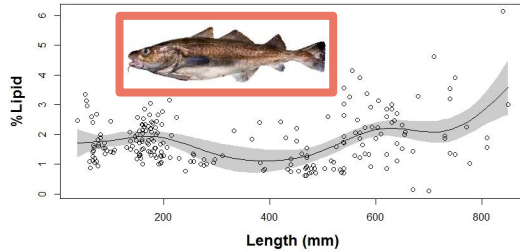


Stallings et al. 2010. Env. Bio. Fish. 88:389-398.

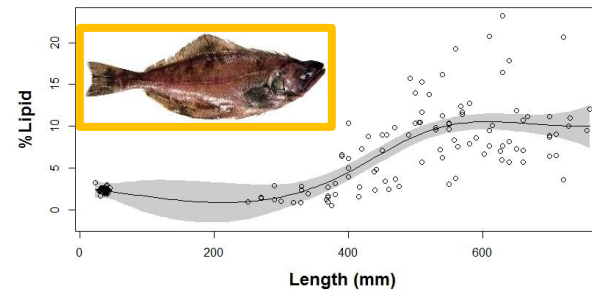
Bell. 2012. TAFS. 141:855-871.

# Energy allocation strategies vary among species

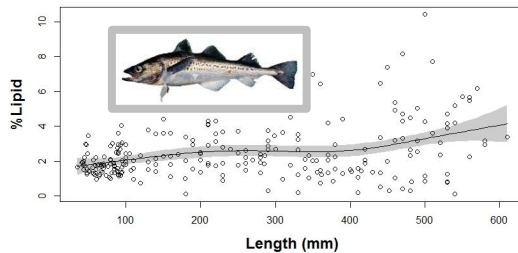
Pacific Cod Lipid Allocation



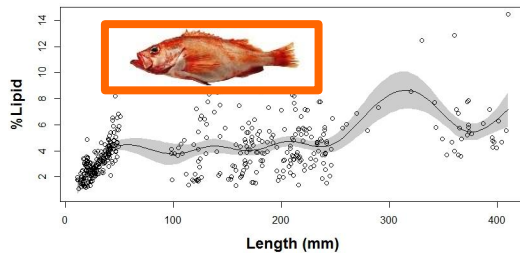
Arrowtooth Flounder Lipid Allocation



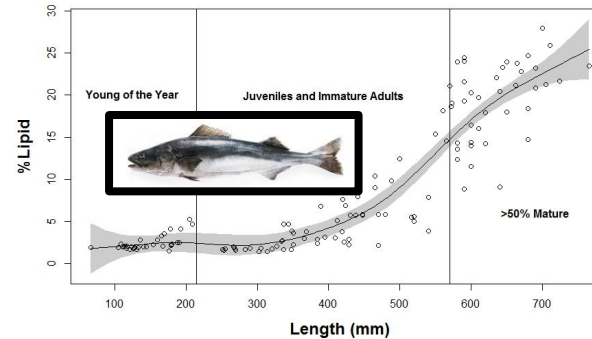
Pollock Lipid Allocation



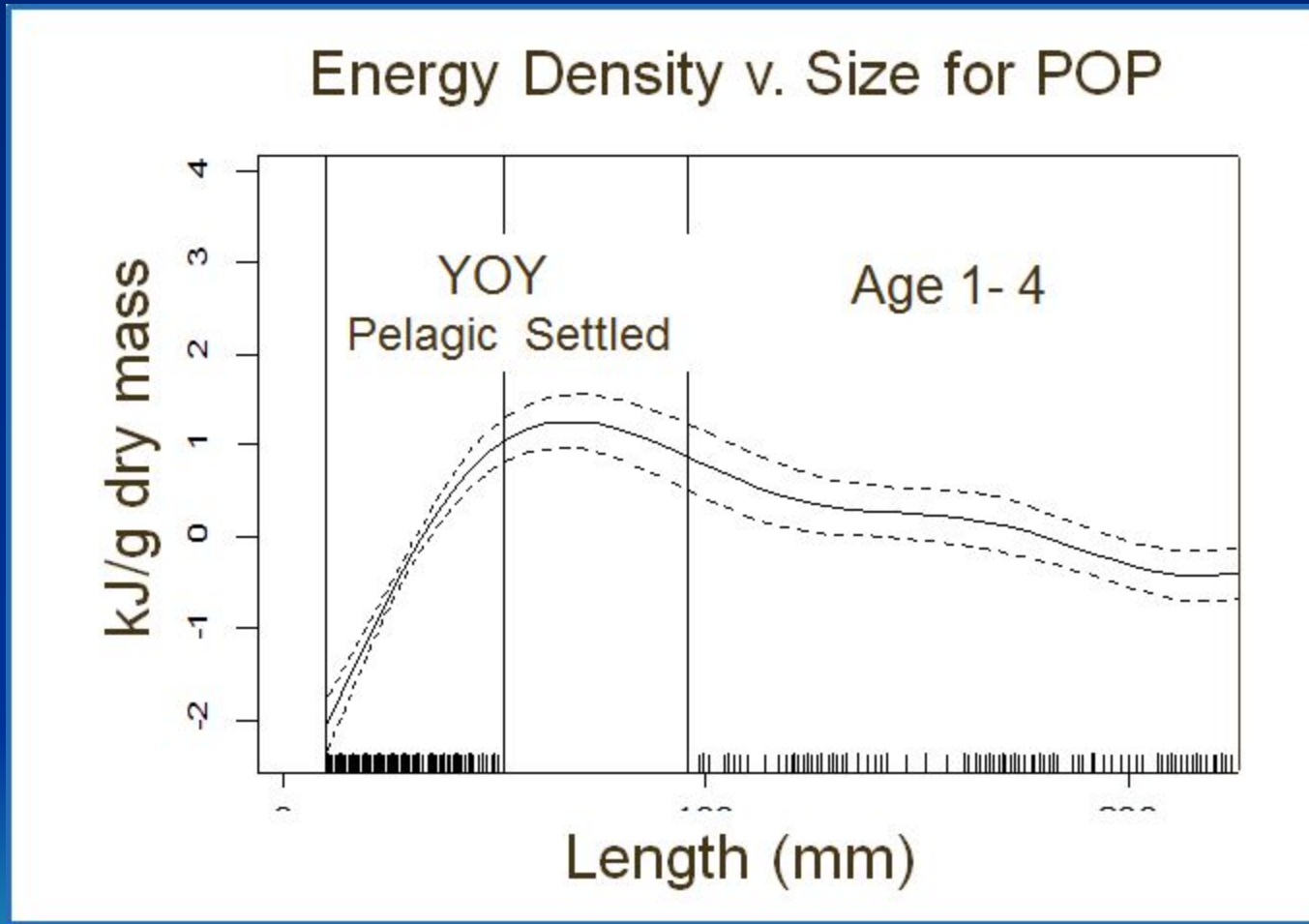
Pacific Ocean Perch Lipid Allocation



Sablefish Lipid Allocation



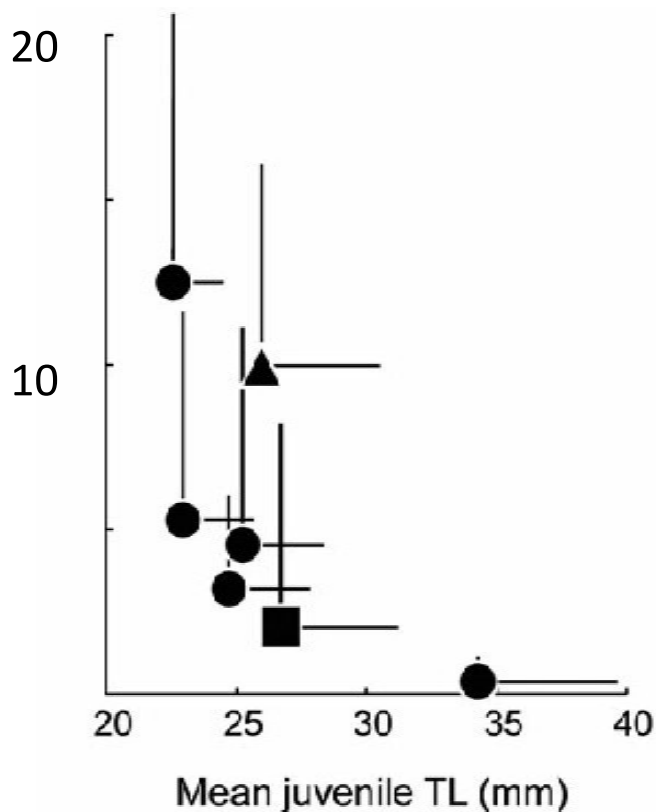
# Settlement Costs for Juvenile Pacific Ocean Perch



Fournier,  
Heintz

# Settled POP Face Significant Mortality

## Predation Rate (%) on YOY Black Rockfish



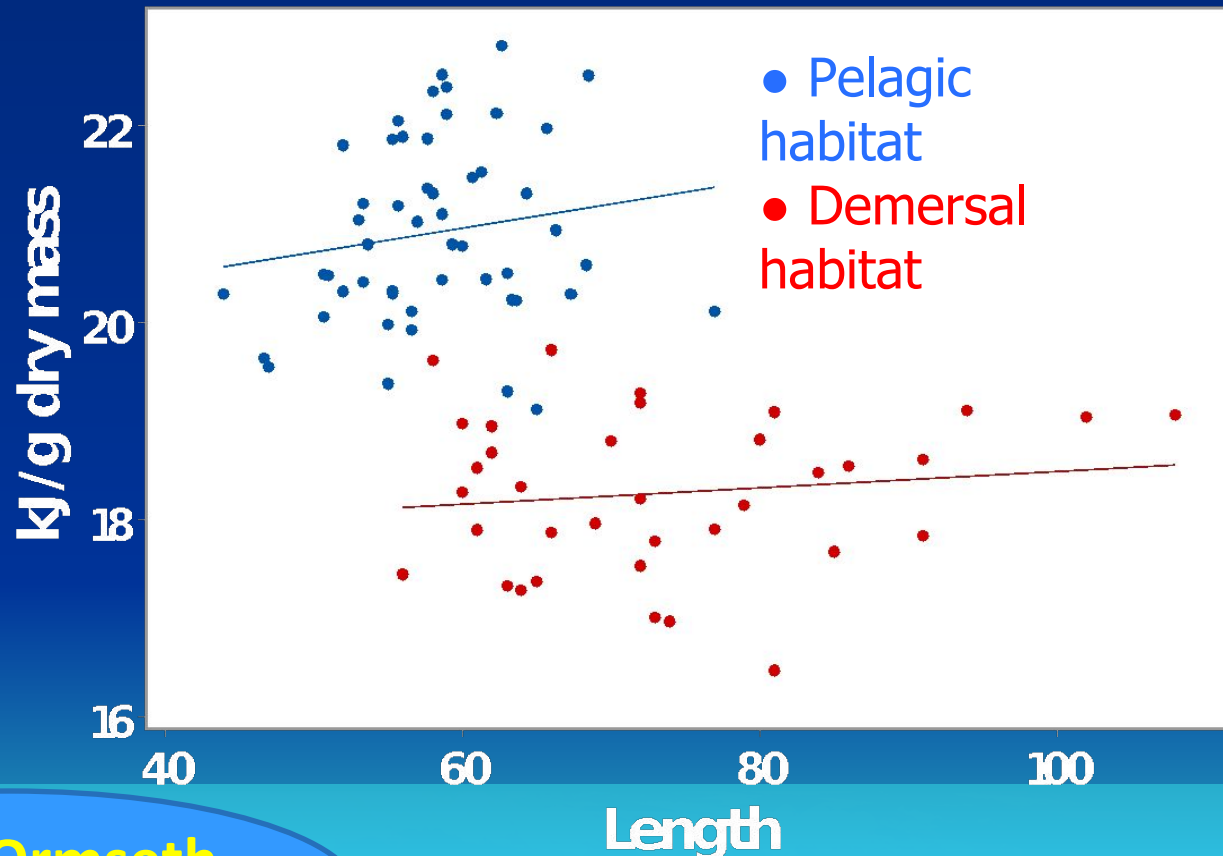
- Mortality is mostly at night
- Growth is highest during the day
- Rapid growth reduces predation risk



# Habitat: Pacific cod

## Energetic condition before and after settlement, central GOA

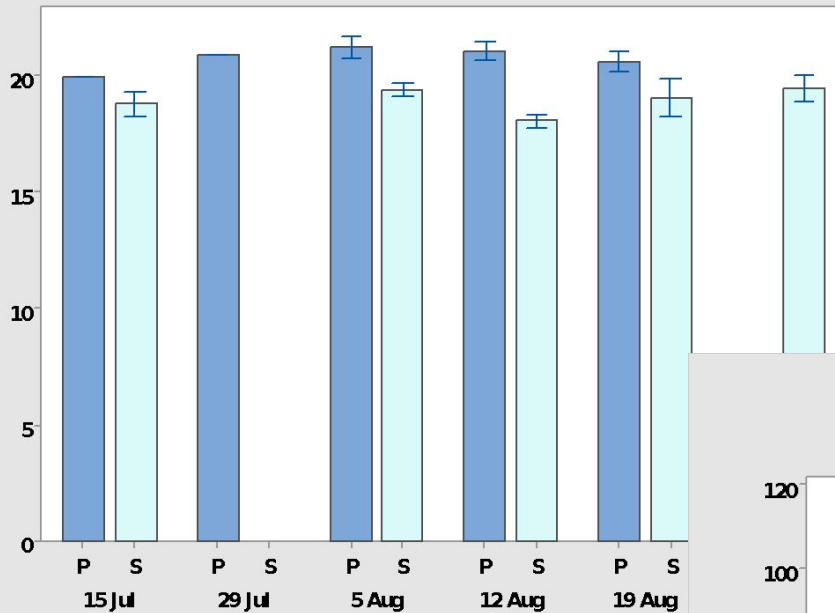
- Recently settled larvae are larger and have smaller lipid stores
- Cost of settlement?



Heintz, Ormseth,  
Budge

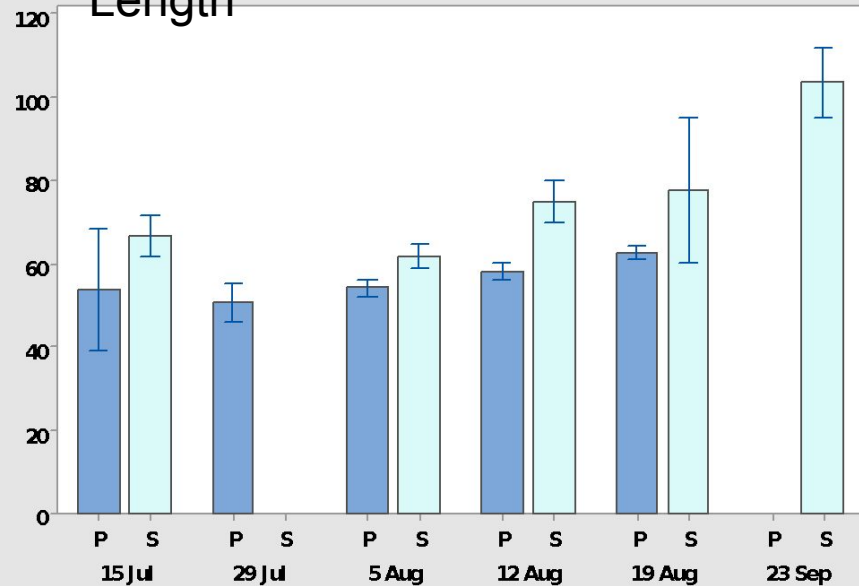
# Settled Age-0 Cod Grow with Lower Lipid

% Lipid



Settling out accompanies  
loss in lipid and  
increasing growth

Length



Pelagic phase

Settled phase

# Bioenergetics Integrates Features Observed on the Gulf Survey and Indexes Ecosystem Status

1. Temperature

2. Food

3. Condition



Arrowtooth Flounder



Pacific Cod



Pacific Ocean Perch



Walleye Pollock

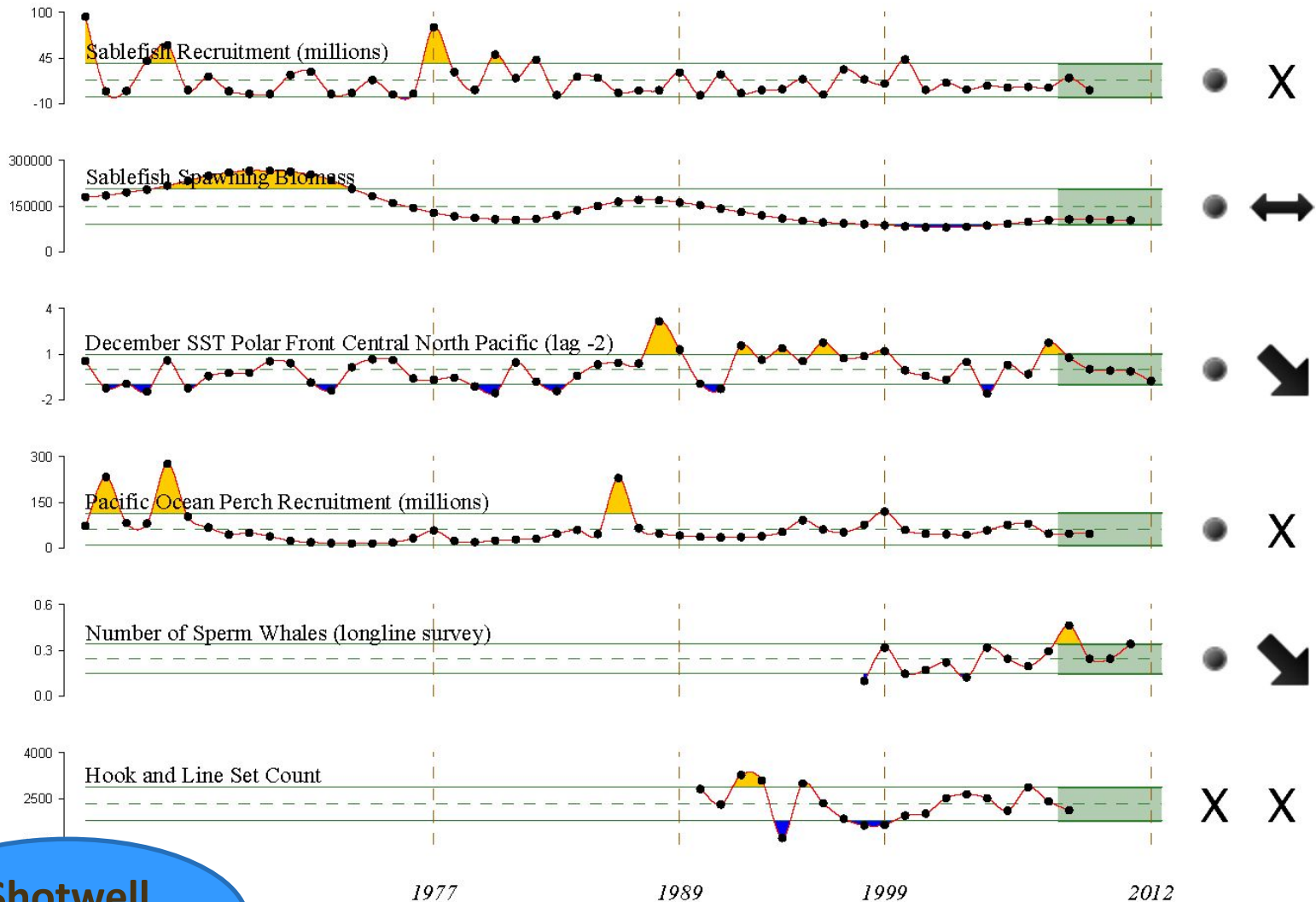


Sablefish

# Management and assessment

- Early life history strategies differ greatly among species
- Hence different indices are needed to capture variability in transport, growth conditions, habitat suitability
- Species specific "report cards" to inform assessment and management

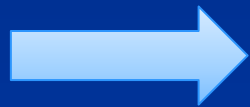
# Sablefish report card



**Shotwell  
Hanselman**

# Management and assessment

- Indices predicting recruitment are promising but likely need refinement before they can improve recruitment estimates in assessment models



Next Steps...

# Stakeholder Outreach at Alaska Marine Science Symposium

